Independent Evaluation of an Out-of-hospital Termination of Resuscitation (TOR) Clinical Decision Rule

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Abstract

Objectives: Recently, investigators described a clinical decision rule for termination of resuscitation (TOR) designed to help determine whether to terminate emergency medical services (EMS) resuscitative efforts for out-of-hospital cardiac arrests (OOHCA). The authors sought to evaluate the hypothesis that TOR would predict no survival for patients in an independent cohort of patients with OOHCA.

Methods: This was a retrospective cohort analysis conducted in the state of Arizona. Consecutive, adult, OOHCA were prospectively evaluated from October 2004 through October 2006. A statewide OOHCA database utilizing Utstein-style reporting from 30 different EMS systems was used. Data were abstracted from EMS first care reports and hospital discharge records. The TOR guidelines predict that no survival to hospital discharge will occur if 1) an OOHCA victim does not have return of spontaneous circulation (ROSC), 2) no shocks are administered, *and* 3) the arrest is not witnessed by EMS personnel. Data were entered into a structured database. Continuous data are presented as means (±standard deviations [SD]) and categorical data as frequency of occurrence, and 95% confidence intervals (CIs) were calculated as appropriate. The primary outcome measure was to determine if any cohort member who met TOR criteria survived to hospital discharge.

Results: There were 2,239 eligible patients; the study group included 2,180 (97.4%) patients for whom the data were complete; mean age was 64 (±11) years, and 35% were female. The majority of patients in the study group met at least one or more of the TOR criteria. A total of 2,047 (93.8%) patients suffered from cardiac arrest that was unwitnessed by EMS; 1,653 (75.8%) had an unwitnessed arrest and no ROSC. With respect to TOR, 1,160 of 2,180 (53.2%) patients met all three criteria; only one (0.09%; 95% CI = 0% to 0.5%) survived to hospital discharge.

Conclusions: The authors evaluated TOR guidelines in an independent, statewide OOHCA database. The results are consistent with the findings of the TOR investigation and suggest that this algorithm is a promising tool for TOR decision-making in the field.

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Despite advances in advanced cardiac life support (ACLS) guidelines and emergency medical services (EMS) provider training over the past 20 years, investigators have continued to observe that survival from out-of-hospital cardiac arrest (OOHCA) is poor for patients whose clinical characteristics suggest high risk for death, regardless of intervention.[1–5] Transport of patients with nearly certain poor outcomes represents an inefficient allocation of limited system resources.[6,7] The financial impact of persistent efforts to resuscitate patients who arrive at the hospital with prolonged field resuscitation times is clearly significant and, yet, difficult to estimate.[1] Further, the cost of hospitalization in cases where spontaneous circulation is restored can escalate to tens of thousands of dollars per patient, even though the majority of these patients do not have meaningful neurologic outcomes.[2,6,7]

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Over the years, researchers have attempted to address these concerns with several guidelines that enable EMS providers to assuredly terminate futile resuscitations of OOHCA victims.[1–4,8–14] In promising recent reports, Morrison et al.[5] and Verbeek et al.[15] derived and subsequently validated such a clinical decision rule for termination of resuscitation (TOR). The TOR guideline predicts that no survival to hospital discharge will occur if a cardiac arrest victim 1) does not have return of spontaneous circulation (ROSC) before transport, 2) does not have shocks administered, *and* 3) does not have an arrest witnessed by EMS personnel.

To date, the TOR criteria have only been validated by the group that developed this rule to determine if it appropriately identifies patients in the field with no chance of survival. The purpose of our study was to independently evaluate the TOR criteria within a large, statewide cohort of patients with OOHCA. Specifically, we sought to evaluate the hypothesis that TOR would predict no survival for patients in our cohort.

METHODS

Study Design

We performed a retrospective analysis of a large cohort of patients with OOHCA. The TOR criteria were applied to this cohort with the purpose of evaluating the clinical decision algorithm. Institutional review board approval for this analysis was obtained from the University of Arizona as part of the Save Hearts in Arizona Registry and Education (SHARE) program.

Study Setting and Population

The study was conducted across the state of Arizona and included data from 30 different EMS systems responsible for approximately 67% of Arizona's population. The state of Arizona encompasses 113,635 square miles with a resident population of 5,939,292, yielding 45.2 persons per square mile. Arizona has 167 fire departments, 84 municipal and 83 rural, which are staffed by 10,063 emergency medical technician (EMT)-Basics, 141 EMT-Intermediates, and 3,898 EMT-Paramedics. EMS system response and dispatch vary significantly across the state, depending on local protocols and resources. The State Bureau of EMS and Trauma Systems (BEMST) establishes the scope of practice, education, training, certification, and vehicle inspection guidelines, while four regional EMS organizations and individual EMS agencies set specific out-of-hospital protocols, including TOR effort guidelines. Providers routinely will not start resuscitation efforts if obvious signs of death are present such as rigor, lividity, or decapitation. We evaluated consecutive adult (age > 18 years) patients who suffered from nontraumatic OOHCA, and for whom obvious signs of death were not present upon EMS arrival (e.g., lividity, rigor, decapitation). The study period was for 2 years, from October 2004 through October 2006.

Study Protocol

EMS personnel provided first-care reports to the SHARE program. The SHARE program research and quality improvement director abstracted data from the first care reports into an Utstein-style format. Outcomes were obtained from the Arizona Department of Health Office of Vital Statistics and from hospital discharge records. The TOR criteria were subsequently applied to each patient to identify those who met all conditions where the rule would predict no survival to hospital discharge.

Data Analysis

Data elements were entered into a Health Insurance Portability and Accountability Act–compliant password-protected Microsoft Access (Microsoft Corp., Redmond, WA) database on an ongoing basis. Continuous data are presented as means ± standard deviations (±SD), and categorical data as frequency of occurrence. We calculated 95% confidence intervals (CIs) using the Exact method. The primary outcome measure was survival to discharge in cohort member who met TOR criteria.

RESULTS

We identified 2,239 patients in the database who were eligible for inclusion into the study. There were 59 patients with inadequate data who were excluded from analysis so the final study group consisted of 2,180 individuals with OOHCA. The mean (±SD) age of the study group was 64 (±11) years and 35% were female. Patient and out-of-hospital characteristics are presented in Table 1. The mean (±SD) on-scene time for adult cardiac arrest patients not witnessed by EMS and with no ROSC prior to transport was 18.3 (±6.4) minutes.

The majority of patients in the study group met one or more of the TOR criteria (Table 1). For the individual TOR criteria, a total of 2,047 (93.8%) patients suffered from an OOHCA that was unwitnessed by EMS providers, 1,433 (65.7%) did not have shocks administered at any time, and 1,726 (79.2%) did not have spontaneous return of circulation. A total of 1,653 (75.8%) had both an unwitnessed arrest and no ROSC. When patients

Table 1
Study Group Data*

N	2,180 patients
Mean age (yr))	64 (±11)
% Female	35%
Mean EMS response time (min)	5.5 (±3.0)
Mean EMS transport time (min)	7.1 (±4.8)
Mean EMS time-on-scene time (min)	18.3 (±6.4)
1) Arrest unwitnessed by EMS	2,047 (93.8)
2) No shock administered	1,433 (65.7)
3) No ROSC	1,726 (79.2)
Met all three TOR criteria (1, 2, and 3)	1,160 (53.2)
Met all three TOR criteria and were transported to the hospital	804 (69)
Patients who met TOR criteria and survived to hospital discharge	1 (0.09; 95% CI = 0%, 0.5%)

CI = confidence interval; EMS = emergency medical services; ROSC = return of spontaneous circulation; TOR = termination of resuscitation.
*Data are presented as mean (±SD) or *n* (%).

met all three TOR criteria (1,160/2,180 = 53.2%), only one (0.09%; 95% CI = 0% to 0.5%) survived to hospital discharge. Of the patients who met the TOR criteria, 804 (69%) were transported to the hospital.

Of note, the sole survivor who met TOR criteria had a relatively good clinical outcome. He was a 66-year-old Hispanic male with a medical history significant for coronary artery disease and insulin-dependent diabetes, and he did not have a prodrome prior to the arrest. The event was witnessed, and bystanders called 911 within 1 minute of collapse. However, bystanders did not perform cardiopulmonary resuscitation. Upon arrival, EMS personnel found the patient to have an initial rhythm of pulseless electrical activity, and ROSC did not occur until after arrival in the ED. He was discharged from the hospital with a Cerebral Performance Score of 2 and was able to care for himself with some help.

DISCUSSION

The goal of any TOR algorithm is to optimize the use of EMS resources while providing an evidenced-based approach for EMS personnel to appropriately identify those patients with OOHCA who might survive with treatment. Our independent evaluation of the TOR criteria across multiple EMS systems in our state appears to support use of this algorithm to terminate out-of-hospital resuscitation efforts by ambulance crews. Within the Arizona-based cohort, 1,160 of 2,180 (53.2%) patients met all three criteria, and only one (0.09%; 95% CI = 0% to 0.5%) survived to hospital discharge. Thus, if TOR criteria were applied by EMS to our cohort, more than half of the victims of cardiac arrest could have been appropriately pronounced dead in the field.

The cost of attempts to resuscitate patients with OOHCA whose clinical characteristics suggest no chance for survival is difficult to estimate. Ambulance calls that result in extended efforts to resuscitate those cardiac arrest victims who will ultimately die, undoubtedly, divert resources from patients whose survival might depend on quicker response times and access to higher-level EMS providers. In addition, we know that high-speed ambulance transports resulted in the death of 27 EMS workers and 275 occupants of other vehicles and pedestrians between 1991 and 2000.[16] Thus, rapid transport of patients with little chance of survival represents a risk to our EMS providers and innocent bystanders.

Studies evaluating the financial costs of these efforts are somewhat dated. In a 1991 report, Gray et al.[2] reviewed the records of 185 patients presenting to the emergency department (ED) after an initially unsuccessful but ongoing resuscitation for OOHCA by an emergency medical team. Only 16 of these patients had ROSC and were admitted to the hospital. None of these patients survived to hospital discharge despite a mean hospital stay of 12.6 days and a total cost of $180,908 (range per patient, $1,984 to $95,144).

As opposed to inpatient expenses, Cheung et al.[6] compared the cost of field pronouncement of death versus the costs of transporting patients to the ED for physician pronouncement.[6] They found that the cost of death pronouncement in the ED was $45.35 higher than the cost of field pronouncement when they compared a cohort of 40 patients matched by six evidence-based predictors of unsuccessful resuscitation (20 in each group). While on the surface this per-patient cost seems low, Bonnin and Swor[1] estimated that such care translated into $500 million spent on unsuccessful field resuscitations (1993 dollars).

For more than 20 years, investigators have recognized the need to develop criteria upon which EMS providers could cease costly, futile efforts at resuscitation in the field. In 1988, Kellermann et al.[3] reported their findings from the review of 240 consecutive patients with available medical records who failed out-of-hospital ACLS care. Although the authors identified 32 patients (13.3%) who were successfully resuscitated in the ED, they noted that only four (1.7%) survived to hospital discharge. Of those four patients, only two had good neurologic outcomes. Kellermann et al.[3] concluded that "Failure to respond to prehospital ACLS predicts non-survival and may warrant cessation of efforts in the field." Similar conclusions were reached by Bonnin and Swor in 1989,[1] when their review of 181 cardiac arrest victims who had failed out-of-hospital resuscitation revealed only one patient (0.6%) who was discharged neurologically intact.

Following the observation that failed out-of-hospital resuscitation for OOHCA victims predicted poor outcome, subsequent investigators sought to specify clinical characteristics of patients that would allow for EMS providers to safely terminate resuscitation efforts in the field.[10,15] Over a period of 18 months, Bonnin et al.[10] prospectively evaluated outcomes for all OOHCAs (1,461) in a large municipality. The authors found that only 0.6% of the 952 patients who did not have return of ROSC at the scene survived, and all six were shown to have persistent ventricular fibrillation. They further observed that all survivors excluding those with persistent ventricular fibrillation had ROSC within 25 minutes after paramedic arrival. Bonnin et al. concluded that resuscitation efforts could be terminated at the scene for normothermic adults with unmonitored, OOHCA who do not regain spontaneous circulation within 25 minutes of provision of ACLS therapy.

With regular advances over time in OOHCA training and equipment (e.g., the provision of automatic electronic defibrillators [AEDs] to EMTs), the TOR investigators have suggested that clinical decision algorithms must be updated to reflect those changes.[15] Using multivariate analysis, they initially derived TOR from a retrospective review of 626 victims OOHCA who received exclusively EMT-D (emergency medical technician-defibrillator) care and for who follow-up data was available. Only two of the 626 patients (0.3%) who failed to achieve ROSC at any time in the field survived to discharge. Their derived rule, the TOR guidelines, had 100% sensitivity (95% CI = 99.1 to 100) in identifying survivors and had 100% negative predictive value (95% CI = 75.3 to 100) for identifying nonsurvivors of OOHCA. The rule included the following criteria for field pronouncement: 1) no ROSC prior to transport, 2) no shock given, *and* 3) arrest not witnessed by EMS personnel.

The TOR investigators subsequently conducted a prospective validation trial of their decision-making algorithm.[5] Their final study group included 1,240 victims of OOHCA, within which only 39 (3.1%) survived to hospital discharge and two remained hospitalized. Of the 776 patients that met the TOR criteria, only four survived (0.5%; 95% CI = 0.1% to 0.9%). Our current study independently confirms the findings of the TOR investigators as only one out of 1,160 patients (0.09%; 95% CI = 0% to 0.5%) in the Arizona-based cohort who met all three criteria survived to hospital discharge.

LIMITATIONS

We examined our database through a secondary analysis of the TOR decision rule rather than through a prospective one, raising the possibility of enrollment bias and problems with data capture. At the time of the study, TOR practices varied widely across the area. Thus, it is plausible that a patient(s) who had field efforts terminated might have had a different outcome if transported to the ED. In addition, we did not test whether paramedics could accurately apply the rule, although we suspect that the interobserver agreement for the individual critierion and the overall rule would be excellent, based on the rule's objective nature. We believe that our results are nonetheless significant because of the large, diverse group of patients that we investigated. Further, we were able to abstract the necessary data to apply the rule to 2,180 patients of the 2,239 who were eligible for inclusion (97.4%) within our statewide database. Certainly, future studies should prospectively apply and implement the TOR criteria to further substantiate our results.

A key difference in our study design is that we included patients treated by all levels of EMS providers, whereas the TOR investigators restricted their focus to those trained and equipped with AEDs. However, the majority of the cardiac arrest first responders within our study group EMS systems are ALS crews that are trained and equipped to provide defibrillation. Therefore, we believe that most of the patients treated in our study group received care from providers with training levels equivalent or higher than those in the TOR study cohort. In addition, we note that an increasing percentage of the first responders in our state are applying a cardiocerebral resuscitation method that has shown promise for improving survival in OOHCA, but does not seem to have impacted our findings for the purpose of this study to evaluate TOR.

Of some ethical concern, our study did reveal one survivor with favorable neurologic outcome who met TOR criteria (0.09%), and similarly there were several survivors in the original TOR validation cohort (0.5%).[5] The survivor in our study had Cerebral Performance Category Scale rating of 2 (moderate cerebral disability: conscious, alert, able to work, might have mild neurologic or psychologic deficit).[17] Clearly, it is beyond the scope of this discussion for our group to define an acceptable "miss" rate for potential survivors. Considering the significance of this issue from a public health standpoint with respect to resource utilization, etc., we would like to see leaders in our specialty and the American Heart Association reach a consensus as to a threshold for survival beyond which a rule is deemed acceptable for widespread use. Although refinements will reduce the specificity of the rule, the original TOR authors have examined changes to the original algorithm that would reduce the likelihood that resuscitation would be halted on a potential survivor. Very recently, Morrison et al.[18] refined their criteria for TOR for patients treated solely by ALS providers, and the rule showed excellent predictive value for identifying patients with no chance for survival from continued treatment.

CONCLUSIONS

We evaluated the TOR criteria in an independent, statewide out-of-hospital cardiac arrest database. Our results are consistent with the findings of the TOR investigation and suggest that prospective studies to implement these criteria will ultimately find that EMS personnel can safely terminate resuscitation efforts according to these guidelines.

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